ORIGINAL RESEARCH

Analysis of Lumbar Spine Stress Injuries in Adolescent Cricket Fast Bowlers

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ABSTRACT
Background: Fast bowling in cricket is associated with a high prevalence of lumbar spine stress injuries, especially in adolescents. This cannot be correlated with risk factors identified in adult players. This study aimed to examine the incidence of lumbar spine stress injuries in adolescent fast bowlers as a prospective study so as to predict risk factors.
Methodology: 32 asymptomatic male fast bowlers (aged 14–17 years) received baseline & annual lumbar dual-energy X-ray absorptiometry (DEXA), magnetic resonance imaging (MRI) scans, musculoskeletal and bowling workload assessment. These were followed up after one year to calculate the prevalence at baseline and annual incidence. Potential risk factors were compared between the injured and uninjured groups using T-tests with Hedges' g effect sizes.
Results: At baseline, 7 cricketers (21.8%) had evidence of lumbar spine stress injury. Subsequent incidence was 27.3 ± 18.6 injuries per 100 players per year (mean ± 95% CI). Injured bowlers were older on average at the beginning of the season preceding injury (16.7 versus 15.5 years, $g = 1.396$, $P = 0.047$)
Conclusion: Risk of lumbar spine stress injury coincides with increases in bowling & cricketing workload as well as intensity as bowlers step up playing levels to more senior teams during late adolescence whilst the lumbar spine is immature and less robust.
Keywords: Cricket; Low Back Pain; Adolescents; Stress Injury.

INTRODUCTION
Bone stress injuries have been demonstrated to progress in severity from bone marrow oedema to stress fracture.[1] Lumbar bone stress injuries (LBSI) are the most prevalent injury in cricket with a time loss which can exceed 8 months[2]and is likely have a deleterious effect on the development of fast bowlers. These injuries to the lumbar vertebrae differ in severity based on the bone stress continuum[3]: from stress reactions to incomplete and complete lumbar stress fractures (LSF). Fast bowling has been associated with asymmetrical bone stress response with injuries occurring more commonly on the contralateral side to the bowling arm (93% of injuries), in the pedicle (23%) and pars interarticularis (77%), and at L4 (35%) and L5 (32%).[2] Despite the high prevalence of LBSI, fast bowlers exhibit substantial lumbar bone mineral with up to 14.6% and 18.1% greater bone mineral density (BMD) and bone mineral content (BMC) on the contralateral side to the bowling arm.[3]

Fast bowling in cricket is a unique and forceful movement pattern defined by extreme trunk movements,[5] great vertical ground reaction forces[6] and high workloads. Compared with other playing roles, fast bowlers are considerably more active,[7] and have greater prevalence of injury than any other playing role.[8]

Three major risk factors have been identified in theliterature. Firstly, the effect of previous injury onsubsequent injury is well established across a numberof sports.[9] Secondly, workload and workload variation have beenidentified as major risk factors for fast bowling injury. Both high andlow overall bowling workloads have been identified as an injury riskfactor.[10] While a high workload would seem intuitive and it has beendemonstrated that bowling more than 50 overs in a match or morethan 30 overs in the last innings of a match leads to an increase ininjury likelihood for the subsequent month,[11] the reason why a lowworkload is dangerous is less clear. Recent research suggests that lowworkloads are a risk factor because they are related to subsequentrapid increases (spikes) in the bowling load, which is also anidentified injury risk factor.[12]

The workload studies[11,12] tend to group all injuries together withthe definition for an injury being the cessation of the current matchand/or loss of subsequent competition. This places all injuries on apar and negates any measure of severity. However, this is not the casewith lumbar stress fractures[13] which lead to longer periods out ofthe game.

Bowling technique is the final of the three identified risk factorsin fast bowling injuries, with biomechanical research indicating alink between excessive shoulder counter-rotation and lumbar spinestress fractures.[14] Biomechanical research is often conducted onadolescent or young fast bowlers[13] or does not clearly identify thedemographics of the injured vs. non-injured groups.[14] So it is unclearwhether the risk factor of poor technique (excessive shoulder counterrotation)continues into the older age groups.[15]It is important to elucidate the relationship of workload to injury risk, to allow workload guidelines to reduce injury risk. The aim of this study to examined the incidence of lumbar spine stress injuries in adolescent fast bowlers as a prospective study so as to predict risk factors.

MATERIALS& METHODS

32 asymptomatic male fast bowlers (aged 14–17 years) were recruited from professional academies or schools and clubs with well-developed cricket programmes. Participants were identified as “fast” bowlers if the wicket keeper would normally stand back from the stumps.[16]

Fast bowlers were included in the prospective injury group if they sustained a LBSI within 2 years following their biomechanical assessment. Bowlers were included in the uninjured group if they had never sustained an LBSI; had a biomechanical assessment prior to the age of 22; and were at least 23 years old with a minimum of 150-match days of professional cricket at the end of the 2022 season.

All bowlers received a baseline pre-season magnetic resonance imaging (MRI) and dual-energy X-ray absorptiometry (DXA) scan and subsequent annual DXA scans and an exit MRI scan after one or two years (22 bowlers), during the cricket pre-season of the respective year.These were followed up after one year to calculate the prevalence at baseline and annual incidence.

INJURY DEFINITION, DIAGNOSIS AND SEVERITY

In 2005, cricket researchers published international injury consensus definitions for the sport and the methods of this survey adhere to the international definitions.[17] The definition of a cricket injury is one that either: (1) prevents a player from being fully available for selection in a major match (which is either a first-class, two-innings per team, or limited overs, which

is one-innings per team) or (2) during a major match, rendering a player unable to bat, bowl or wicket-keep when required by either the rules or the team's captain.
Severity of the injury was determined by the cumulative numbers of matches missed which was calculated for each injury until the player returned to play.
All radiological scans were read by board certified musculoskeletal radiologists with extensive experience in reporting lumbar spine scans in fast bowlers. LBSI's were defined as either stress reactions or stress fractures determined from radiological reports Stress reactions were defined as any report which identified evidence of bone marrow oedema (without fracture line), while acute stress fractures were defined by any report which identified evidence of incomplete, complete or multilevel stress fracture accompanied by bone marrow oedema which suggested the fracture site was active. Chronic inactive stress lesions were identified separately in separate analysis.

BOWLING WORKLOAD

Bowling workload was self-recorded using an online questionnaire in which participants detailed the number of balls bowled per day. The following variables were calculated: total balls bowled during the season, the number of bowling days per week (for weeks in which they were bowling) and the peak acute (7-day) and medium-term (90-day) workload during the cricket season.

MUSCULOSKELETAL ASSESSMENT – FLEXIBILITY AND RANGE OF MOTION (ROM)

A trained researcher (LK) performed a musculoskeletal assessment protocol (Supplementary material) in both legs (ipsilateral and contralateral to bowling arm), prior to bowling which was found to be reproducible in a preliminary reliability study (ICC $\geq$ 0.946). The protocol included passive hip internal and external rotation, bent knee fallout, passive straight leg raise, sit and reach, and ankle dorsiflexion.

STATISTICAL ANALYSIS

All statistical analyses were performed within SPSS v.22.0. To compare variables between injured and uninjured fast bowlers, independent samples t-tests were used with an alpha value of 0.05. Potential risk factors were compared between the injured and uninjured groups using T-tests with Hedges' g effect sizes.

RESULTS

At baseline, 7 cricketers (21.8%) had evidence of lumbar spine stress injury. Subsequent incidence was 27.3 ± 18.6 injuries per 100 players per year (mean ± 95% CI). Injured bowlers were older on average at the beginning of the season preceding injury (16.7 versus 15.5 years, g = 1.396, P = 0.047). No bowlers who sustained injuries prospectively were injured at baseline and details of individual LBSI can be found in Table 1.

Table 1: Baseline and prospective lumbar bone stress injuries that occurred in adolescent fast bowlers.

Characteristics		No. of LBSI		LBSI/bowler or LBSI/ 100 bowlers/year at Baseline
		Baseline (N=7)	Prospective (N=5)	
Age (yrs)	**14 yrs**	2	0	0.18*
	15 yrs	1	0	0.087*
	16 yrs	3	2	0.424*
	17 yrs	1	3	0.16*
Maturation	**Delayed**	1	1	

	Normal	5	4	
	Advanced	1	0	
Lumber level	**L2**	1	0	
	L4	1	1	
	L5	4	2	
	Multilevel	1	2	
Side	**Ipsilateral**	1	0	
	Contralateral	5	5	
	Bilateral	1	0	
Severity	**Bone stress**	5	2	
	Incomplete stress fracture	2	3	

Only chronological age significantly between prospectively injured and uninjured bowlers (P <0.05*), with a large effect size (g = 1.396; Table 2). Injured bowlers were 1.2 years older at the beginning of the season preceding injury than uninjured bowlers. There were also four further non- significant (P >0.05) large effect sizes of L3 and L4 contralateral BMD (g ≥ 0.811). Three participants also experienced lower back pain during bowling, which required physiotherapy treatment and rest from bowling.

Workload was self-reported for 15 players in total, five of whom were included in the injured group. Total, peak acute and medium workloads were non-significantly higher in injured than uninjured players P > 0.05) (table 2).

Table 2: A comparison of uninjured and prospectively injured fast bowlers

Characteristics	Prospectively injured group (N=5)	Uninjured group (N=27)	P-value	Hedges'g effective size
Chronological age (yrs)	16.7 yrs	15.5 yrs	<0.05*	1.42*
L3 CL BMD (gm/cm^2)	1.618	1.422	>0.05	0.811*
L4 CL BMD (gm/cm^2)	1.656	1.435	>0.05	0.850*
Total balls bowled (no. of balls)	62.3	55.3	>0.05	0.604*
Bowling days per week (no. of days)	60.4	55.2	>0.05	0.395*
Peak acute workload (no. of balls)	68.5	67.6	>0.05	0.022

DISCUSSION

The prevalence of LBS injuries in athletic populations is higherthan in the general community, with figures of 8%[18] and 15%[19] reported. However, prevalenceis higher in particular sports, specifically cricket in which the prevalence for stress lesions inbowlers is between 11 and 67%.[20]

Bowlers who developed new LBSI prospectively during the study were significantly older than uninjured bowlers on average at the start of the season preceding injury (16.7 versus 15.5 years, respectively), with all LBSI occurring at 17 and 18 years of age. Increases in workload and bowling intensity, as well as muscle mass and body size, may increase bone

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strain in the posterior elements of the lower lumbar spine during bowling. This could in turn increase LBSI risk as microdamage accumulates and propagates at a greater rate than can be repaired and before bone can adapt its mechanical competence to the increased typical loads.[21]

Further mediating the age-related anatomical differences in susceptibility to lumbar bony stress injuries may be the biomechanical impact of different bowling styles. Ranson et al. (2008)[5] have suggested that excessive contralateral trunk side-flexion coupled with large loading may cause bony stress injuries in adult (>20 yr) fast bowlers. However in adolescent fast bowlers, a high degree of shoulder counter-rotation (possibly due to poor technique) may be a specific factor increasing the risk of injury in these younger players.

Site-specific low BMD in the lumbar spine has also been identified in lumbar stress fracture cases in senior fast bowlers[2], although this was assessed in bowlers who had previously been injured and was also statistically non-significant. It would be logical to suggest that low bone density may be implicated in the aetiology of bone stress injury as bone density is a large determinant of bone strength[22]; thus, low bone density would decrease the mechanical competence of bone. However, bowlers who suffered LBSI in our study had non-significantly greater contralateral side BMD on average as well as greater vertebral area at the beginning of their year of injury. This could be due to the comparatively greater chronological age of the group or related to the increased bowling volume, intensity and muscular strength demands. Yet, this still may not have been sufficient to withstand fast bowling loading, suggesting that bowling workload may be dependent on lumbar BMD to prevent LBSI.

The injurious result of acute peaks in workload may be dependent on the long-term career workload[23]meaning conditioned, mature bone, which is likely evident in bowlers who have reached full lumbar adaptation to fast bowling, may be better able to withstand an increase in acute workload, but young, under-adapted, immature bone may not be robust to sudden spikes.

The large forces involved in fast bowling may generatehigh strain rates in the neural arch that may be closeto, or exceed, the threshold for microdamage, particularlyin young bowlers and/or those who are less well adapted.[24] Once the microdamage threshold range is exceeded, microdamage may occur. With a high workload, microdamage may accumulate and propagate stimulating bone resorption that may increase crack propagation with continued loading, resulting in stress fracture.[24] As LSF is a gradual-onset injury, it is unlikely that symptoms will manifest immediately, so fast bowlers continue to bowl in a state of pathological overload, reflected in cases at the end of the season, where their 90-day workload was significantly greater than controls for the 81 days leading up to LSF.

CONCLUSION

Risk of lumbar spine stress injury coincides with increases in bowling & cricketing workload as well as intensity as bowlers step up playing levels to more senior teams during late adolescence whilst the lumbar spine is immature and less robust.

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